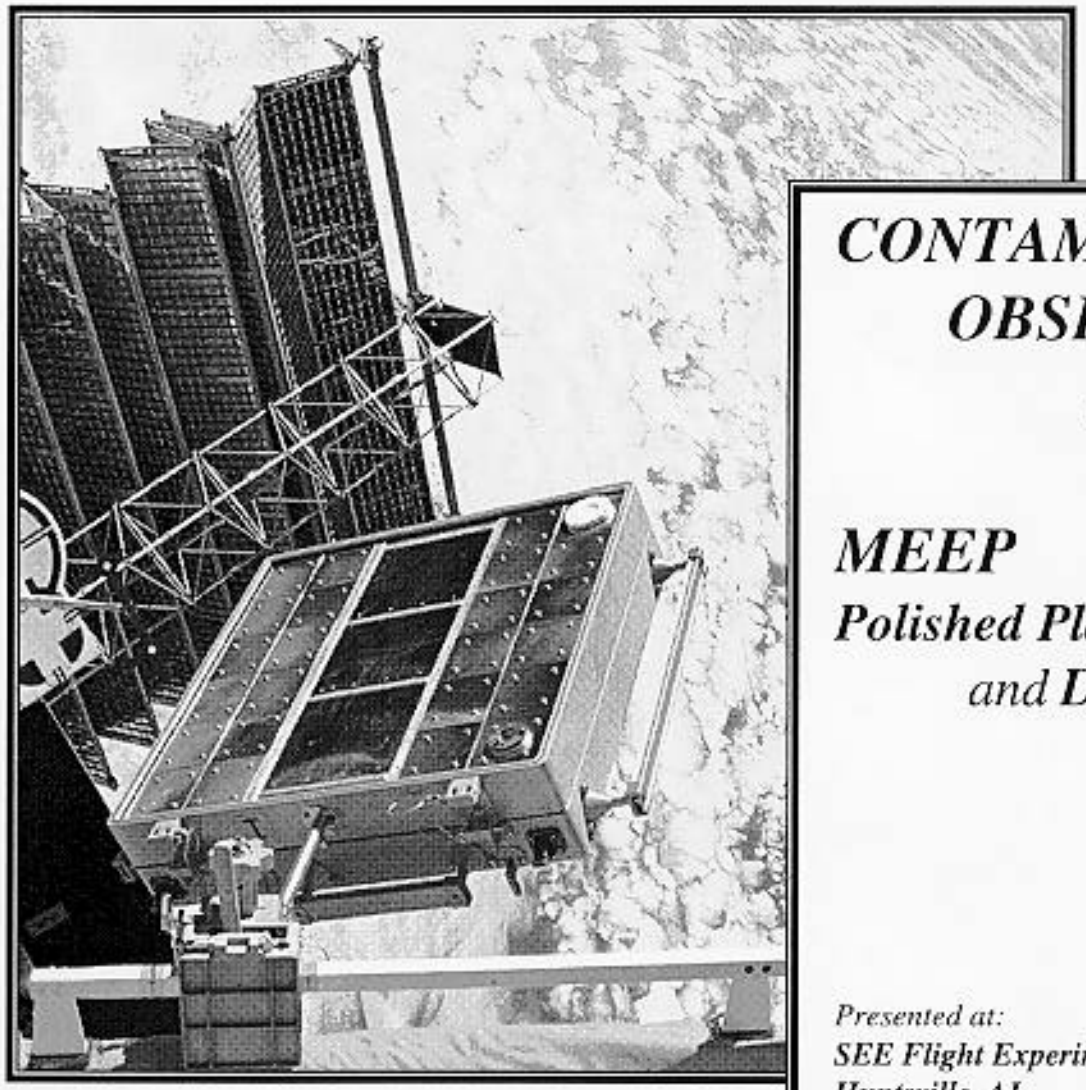

CONTAMINATION OBSERVATIONS & ANALYSIS

on

MEEP

Polished Plate Meteoroid and Debris Experiment

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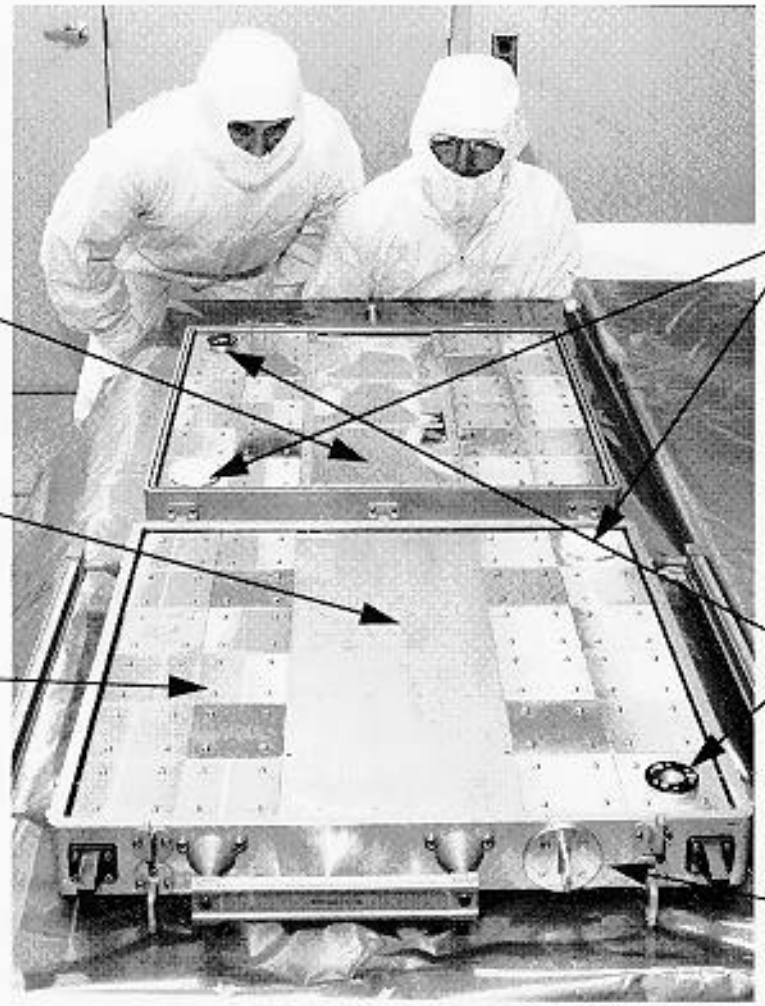
TOPICS

- *PPMD Experiment hardware , preflight cleanliness and mission profile*
- *On orbit and post flight visual observations of contaminants on hardware surfaces*
- *Microscopic examination of contamination spots and comparison to spots simulated with Mir and STS waste fluids*
- *Chemical analysis of contamination spots and comparison to chemical analysis of spots simulated with Mir and STS waste fluids*
- *Summary and conclusions*

PPMD EXPERIMENT HARDWARE



PREFLIGHT CLEANING of PPMD EXPERIMENT HARDWARE

- *Most PPMD flight hardware was cleaned to a cleanliness level of CL 200 A/8 or better.*

- *Cleaning protocols used were as follows:*

  a) pollshed Zn plates were ultrasonicated with technical grade IPA for 15 min., syringed with analytical grade IPA, and blown dry with GN_2;

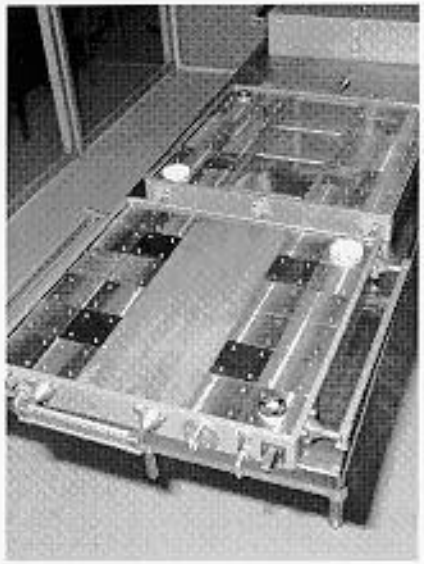
  b) other Zn plates were precleaned with hot sudsy ammonia, rinsed in hot water, scrubbed with glycol ethers, rinsed in hot water, scrubbed with hot sudsy ammonia, rinsed in hot water,and blown dry with GN_2. After precleaning, they were then ultrasonicated using the same protocol as used for the polished Zn plates;

  c) aluminum plate was blown with GN_2, soaked 2 days in trichlorotri-fluoroethane and then ultrasonicated for 15 min. in trichlorotri-fluoroethane with an IPA cap, syringed with analytical grade IPA, and blown dry with GN_2;

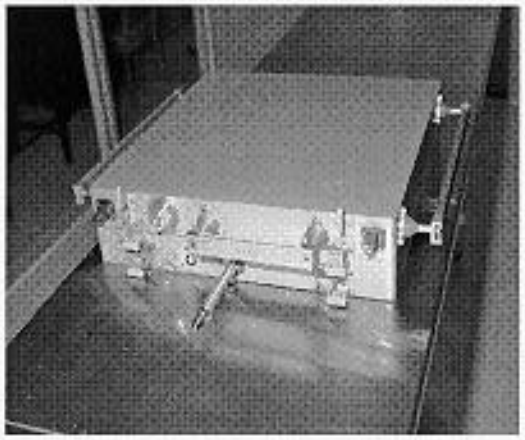
  d) Au plate was precleaned using the protocol used for the Zn plates and ultrasonicated using the protocol used for the aluminum plate.

PPMD Experiment Mission Sequence

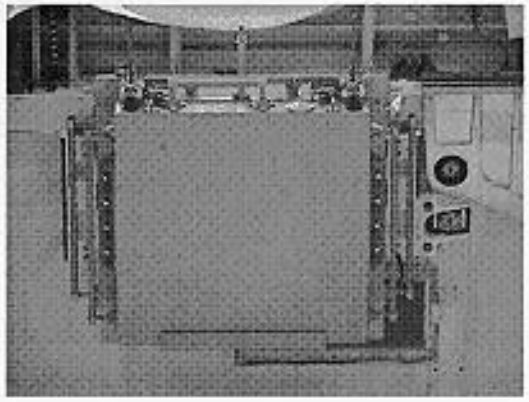
(Launch mission illustrated - steps reversed in retrieval mission)



1. Installed experiment hardware- Impact witness plates(Al, Zn & Au), contamination collectors (MgF), and A.O. cameras in PEC.



2. Closed PEC, with installed experiment hardware ready for shipment to KSC & integration in Orbiter.



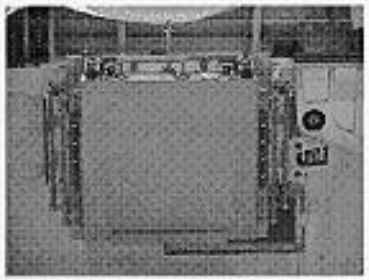
3. Closed PEC with experiment hardware after integration in Sidewall Carrier and ICAPC in Orbiter cargo bay. Launch ready.

4. Opened PEC with exposed experiment test specimens clamped to handrail on Mir Orbiter Docking Adapter. (EVA operation)

OPENING SEQUENCE FOR PEC'S

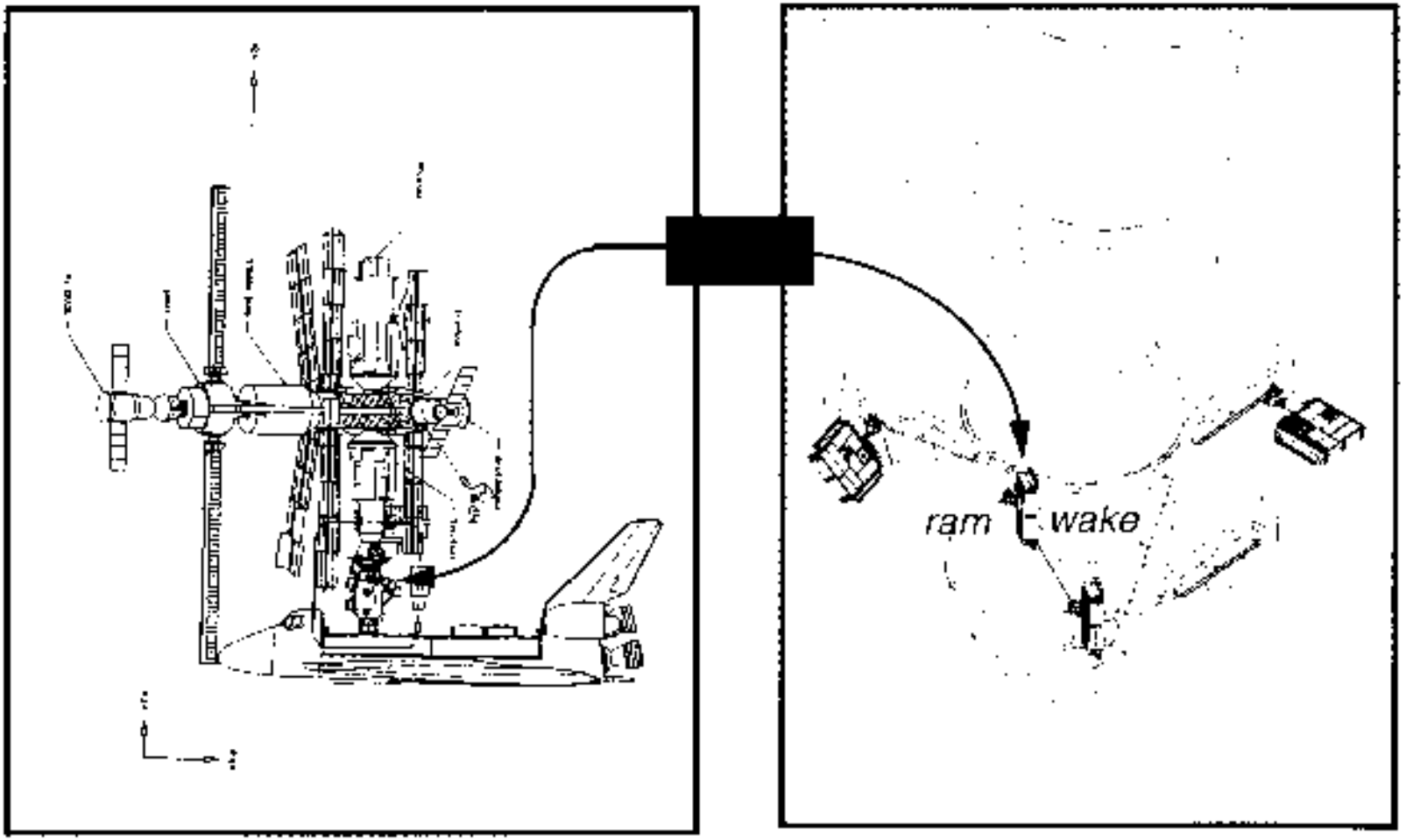
(AFTER THEY ARE MOUNTED ON HOST SPACECRAFT)

Closed PEC in launch & retrieval configuration

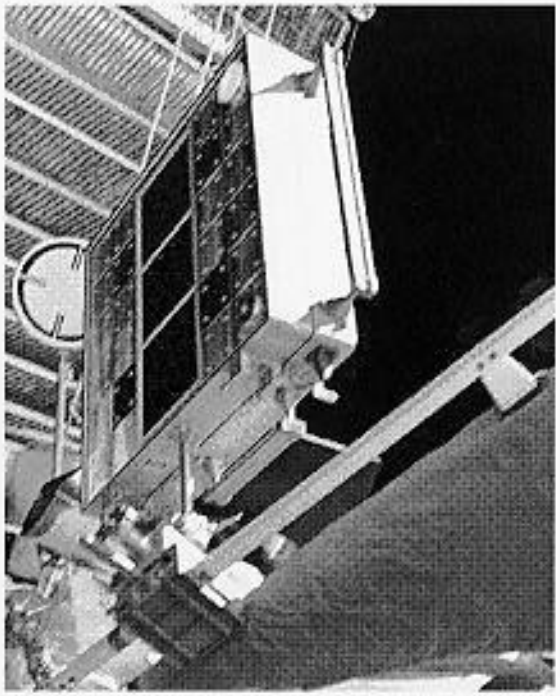


Open PEC in space exposure configuration

PPMD ORIENTATION ON MIR



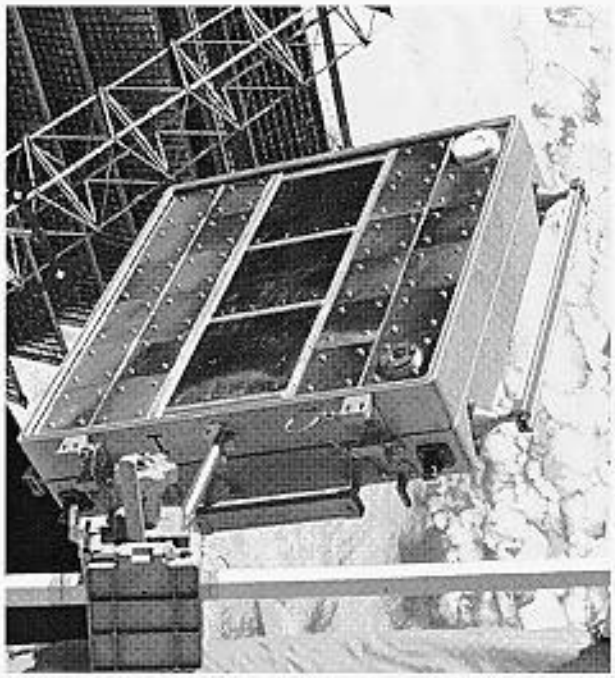
PPMD EXPERIMENT WHILE EXPOSED ON MIR



- *Just after deployment (STS-79).*
- *No visible contamination.*

Note:

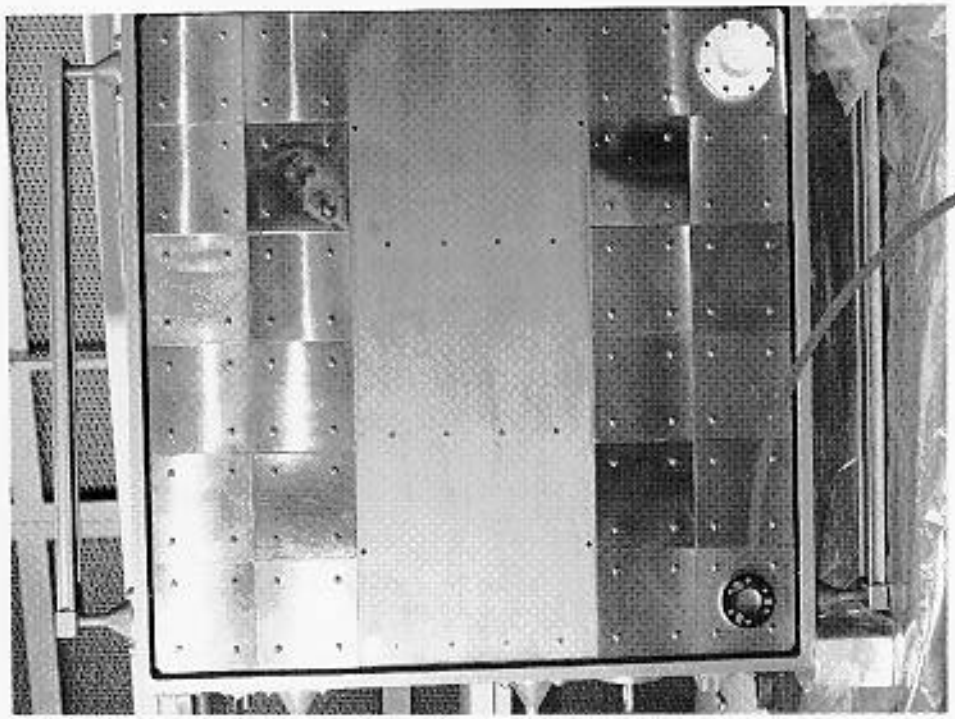
Only ram facing side of PPMD was photographed while on-orbit.

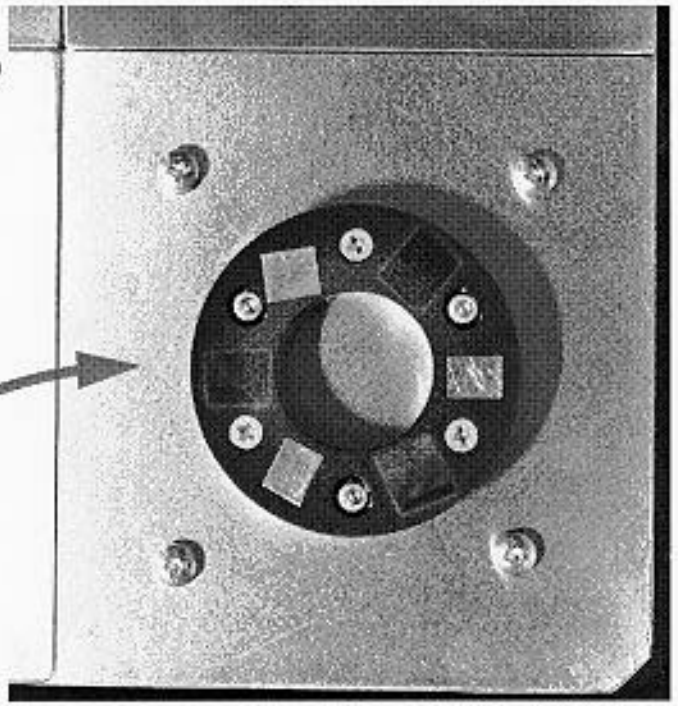


- *Just prior to retrieval (STS- 89).*
- *Contamination spots visible on experiment surfaces, edge of PEC and on the Docking Module Handrail.*

PPMD WAKE-SIDE SURFACES

- *Post flight examinations revealed no visible contamination on wake-side surfaces.*



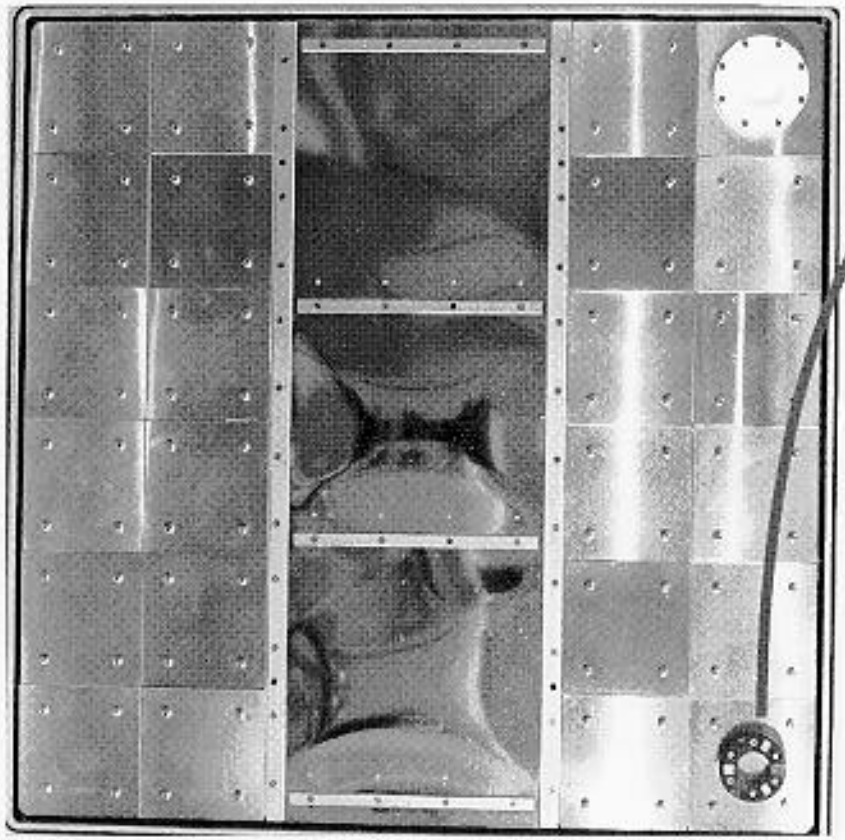


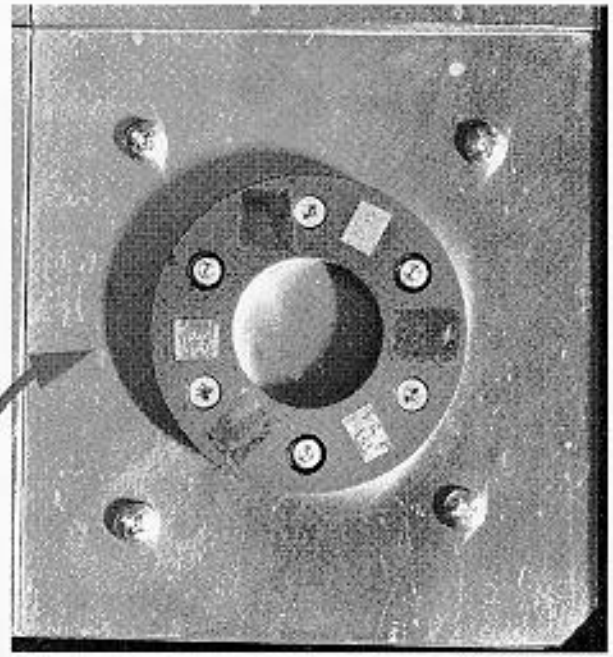
Specimens to aid in the monitoring of contamination

- **MgF window**
- **Al tape**
- **Kapton tape**

PPMD RAM-SIDE SURFACES

- *Contamination spots visible in post flight examinations of all ram-side* surfaces.*



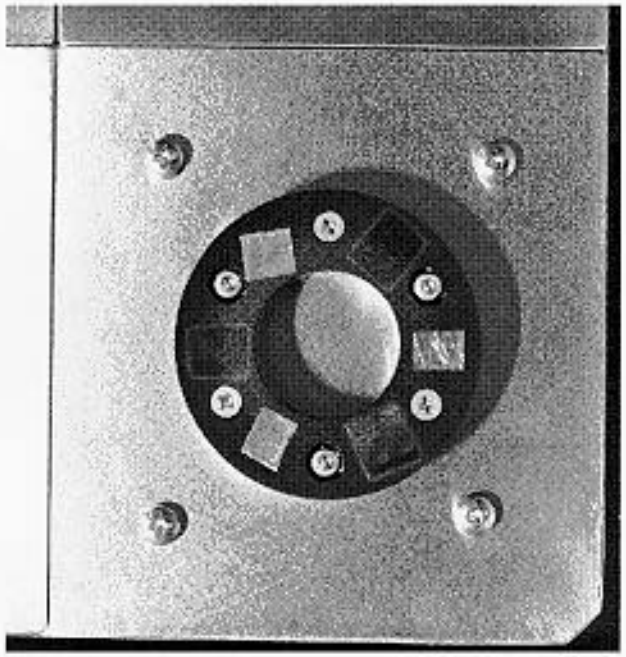


Specimens for Contamination Monitoring

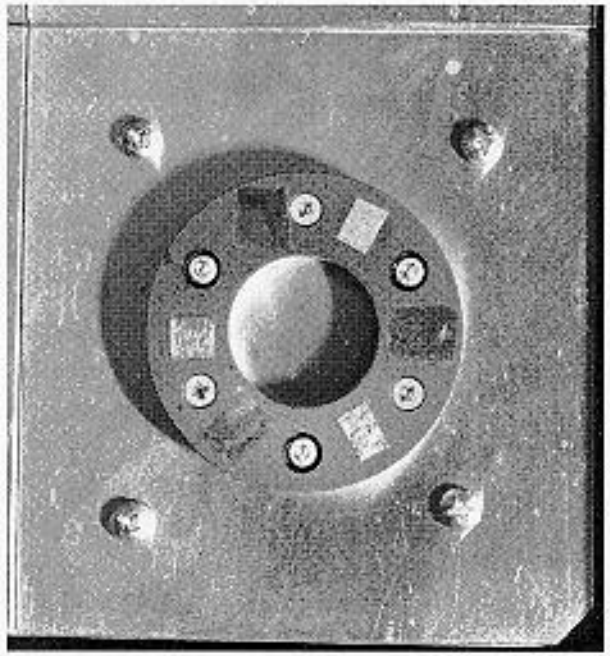
* ***Note:***
This side generally faced in the ram direction, however, the orientation of Mir was frequently changed for temperature and power considerations.

Comparision of PPMD Wake and Ram Surfaces

- *Specimens flown on PPMD to aid in the monitoring of contamination.*



Wake Surface

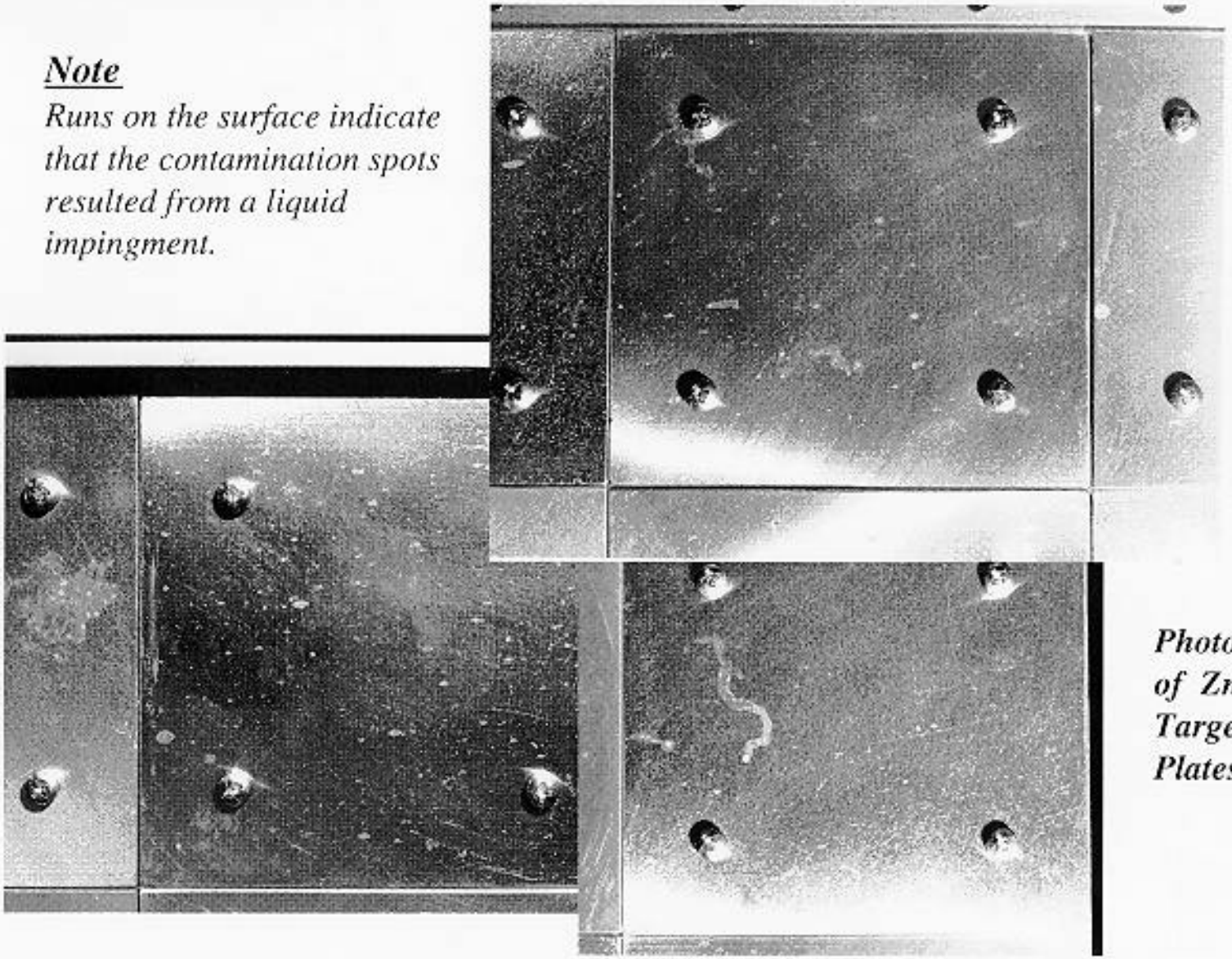


Ram Surface

PPMD RAM-SIDE SURFACE-CONTAMINATED

Note

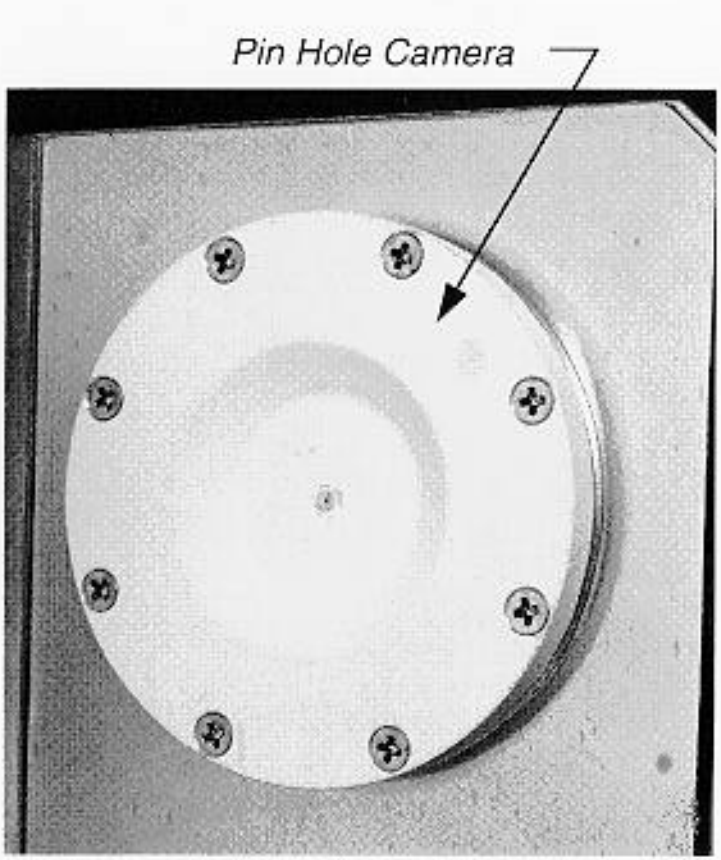
Runs on the surface indicate that the contamination spots resulted from a liquid impingment.

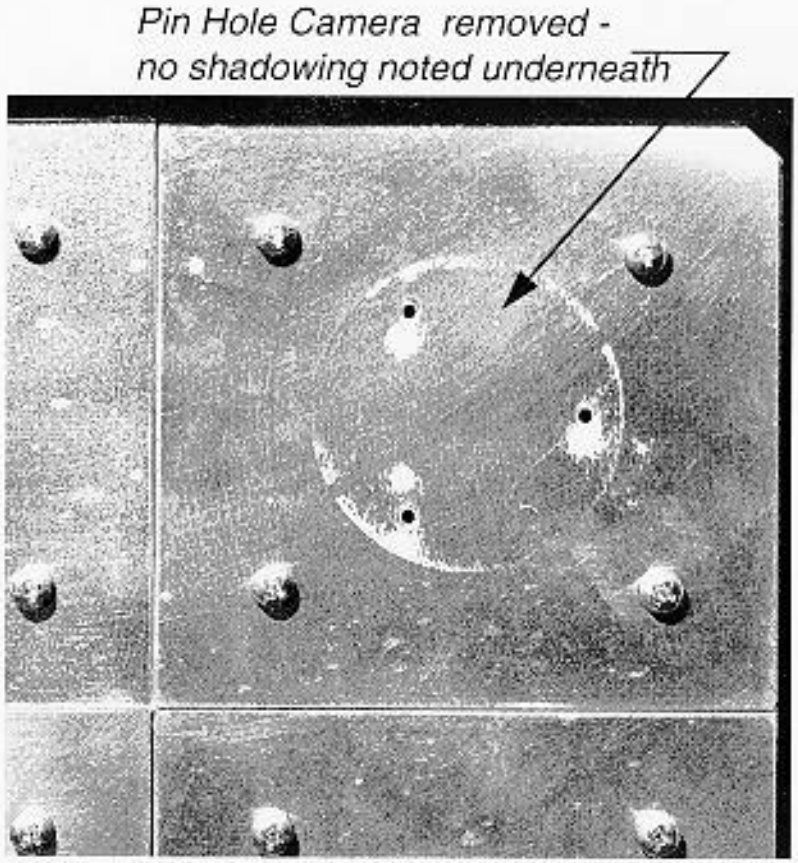


Photos of Zn Target Plates

MOLECULAR CONTAMINATION on PPMD

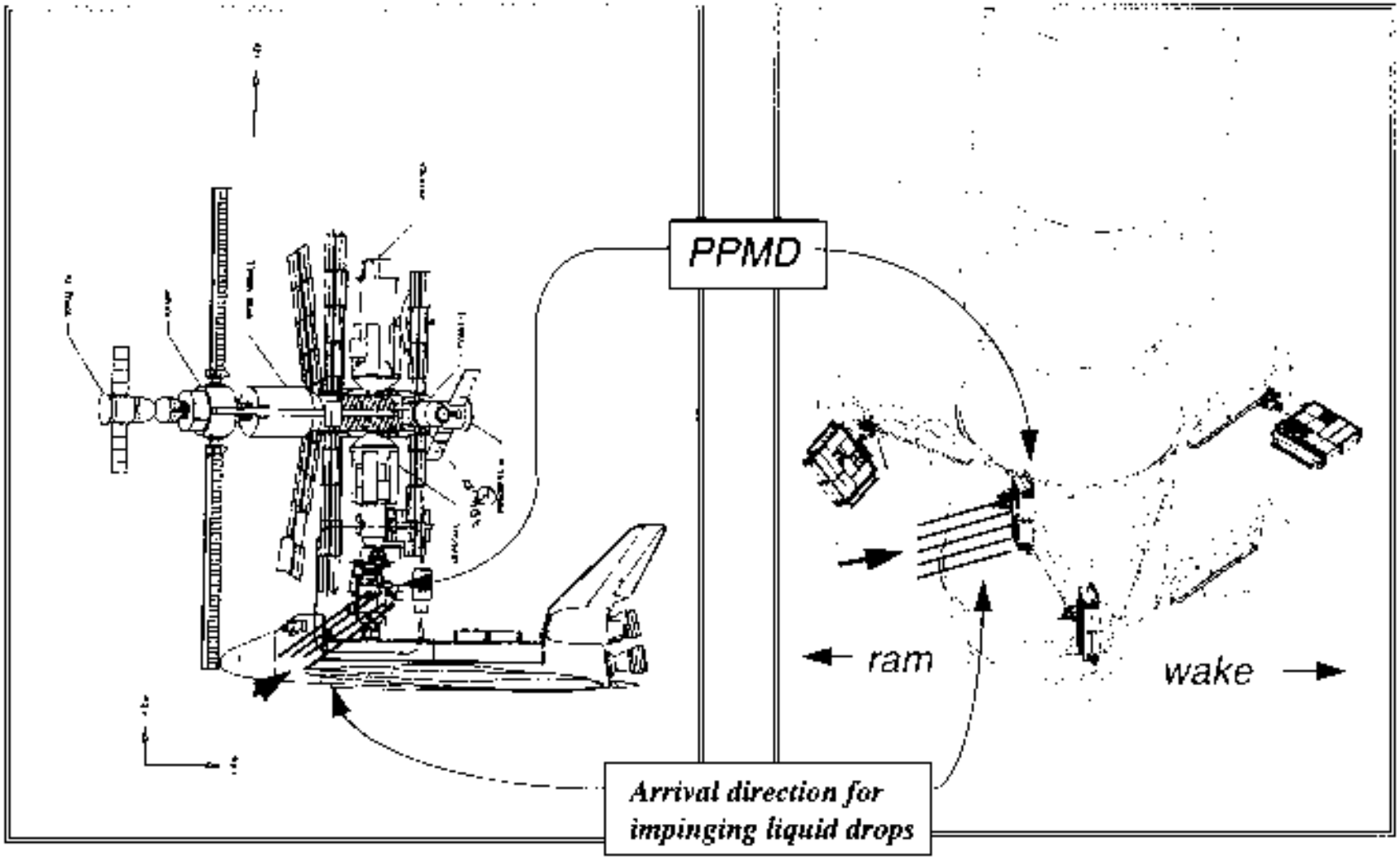
- ***No molecular contamination was visible on any of the PPMD surfaces. However, Energy Dispersive Spectra do indicate a thin layer of silicon deposited on most of the surfaces.***





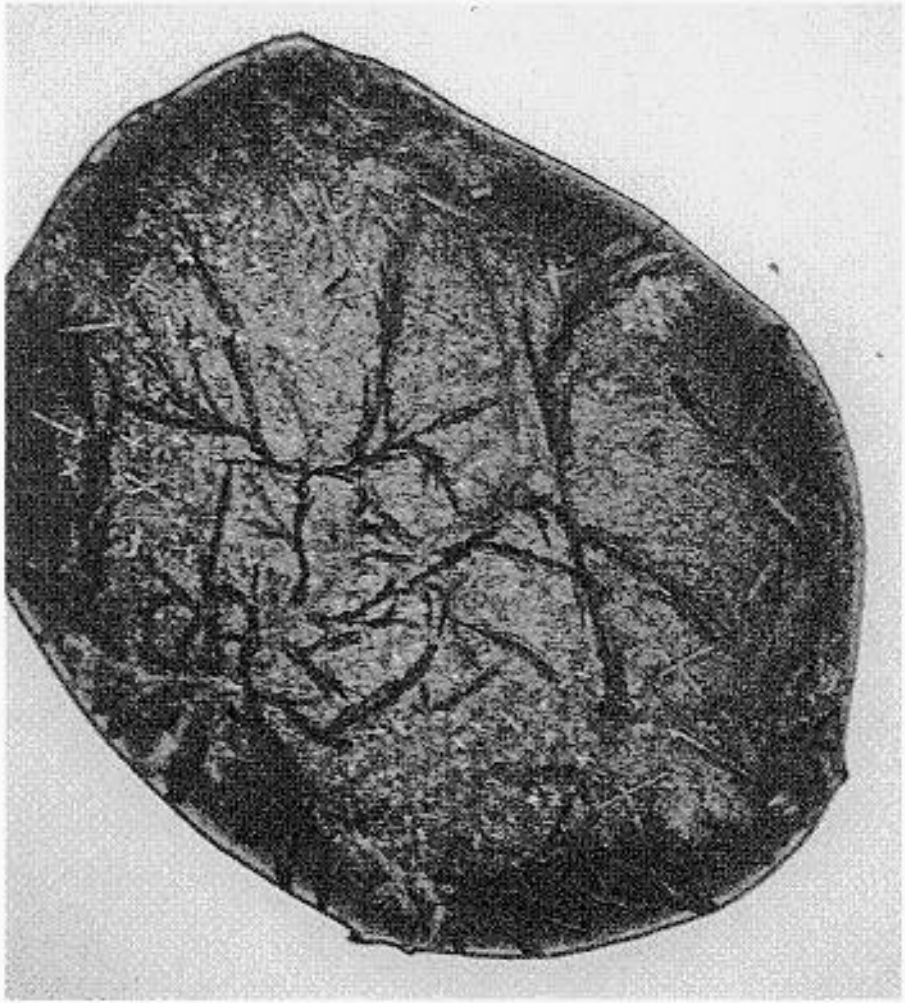
ARRIVAL DIRECTION for IMPINGING LIQUID

- Established from the 3 PPMD PEC surfaces that were impacted by liquid drops and the elongation of the individual dried spots.



CRYSTAL STRUCTURE IN SPOTS ON PPMD

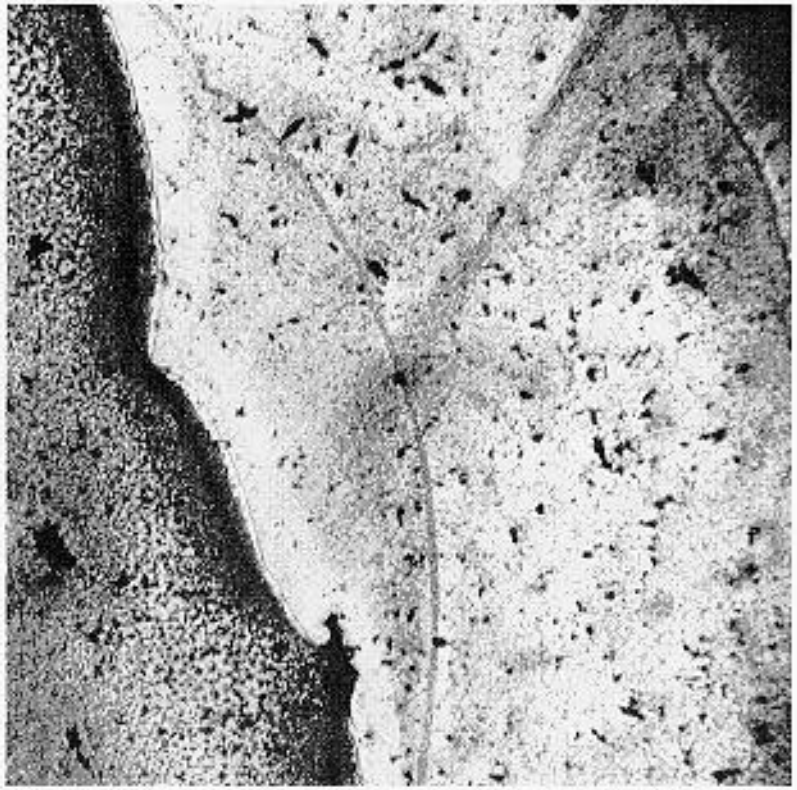
- *Crystal structure was difficult to observe in many PPMD spots. However when observable, the structure appeared feather like as shown in this microscope 50X photograph.*



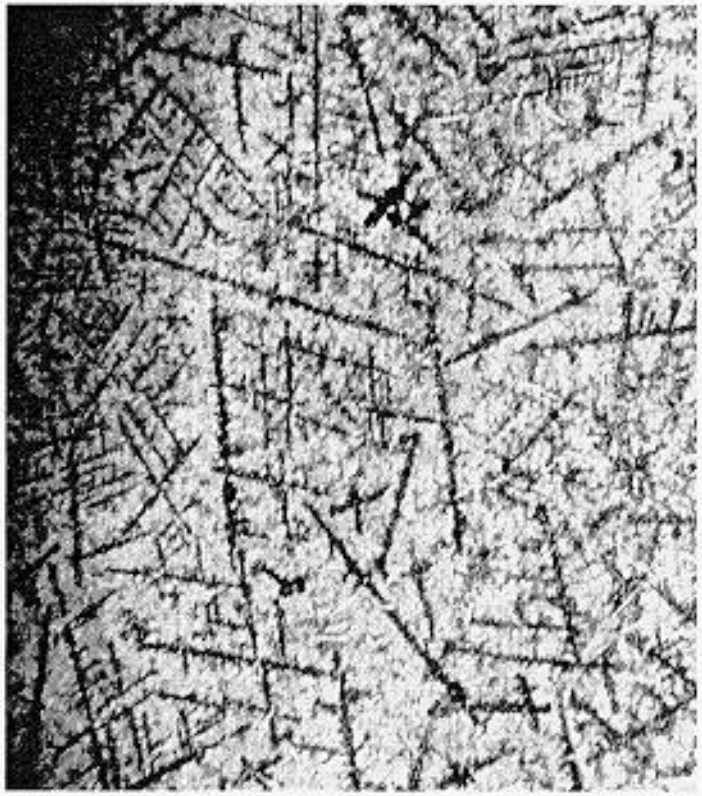
Note:
This spot is on the PPMD CaF_2 Window.

CRYSTAL STRUCTURE IN SIMULATED SPOTS

- ***Microscope 50X photographs of spots produced by vacuum baking drops of STS-89 waste fluid and doped Mir waste fluid on Ge surfaces.***



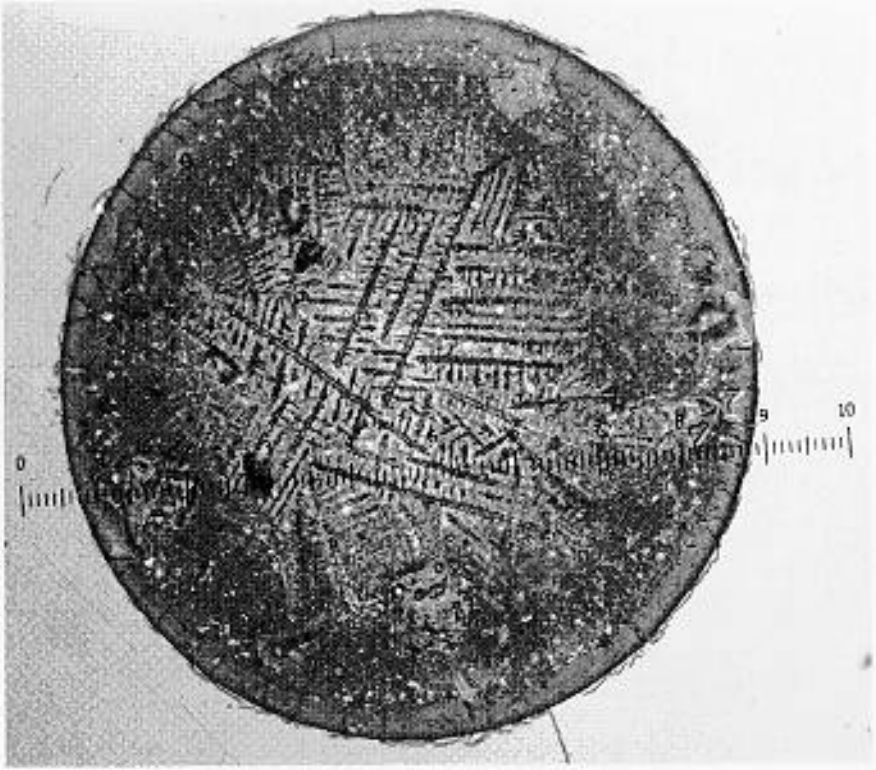
Spot from doped Mir waste fluid



Spot from STS-89 waste fluid

Comparision of Spot Observed on LDEF with Spot Simulated from STS 89 Waste

- *Crystal structures match -*



Spot observed on LDEF

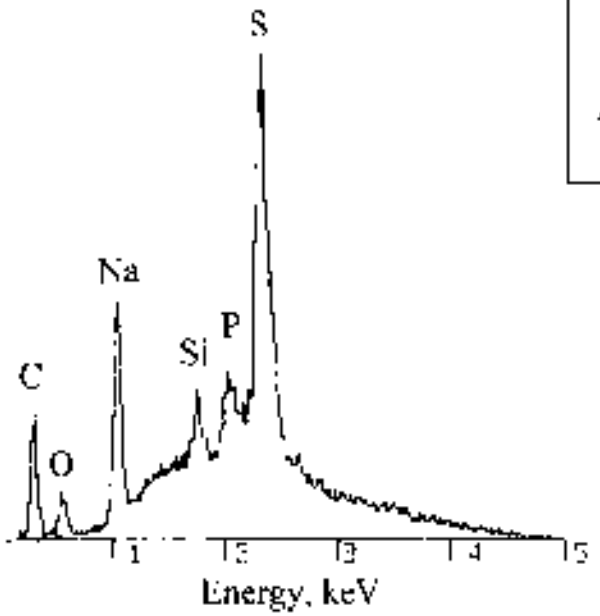
Spot from STS-89 waste fluid

EDS Spectra of Spots on PPMD Surfaces

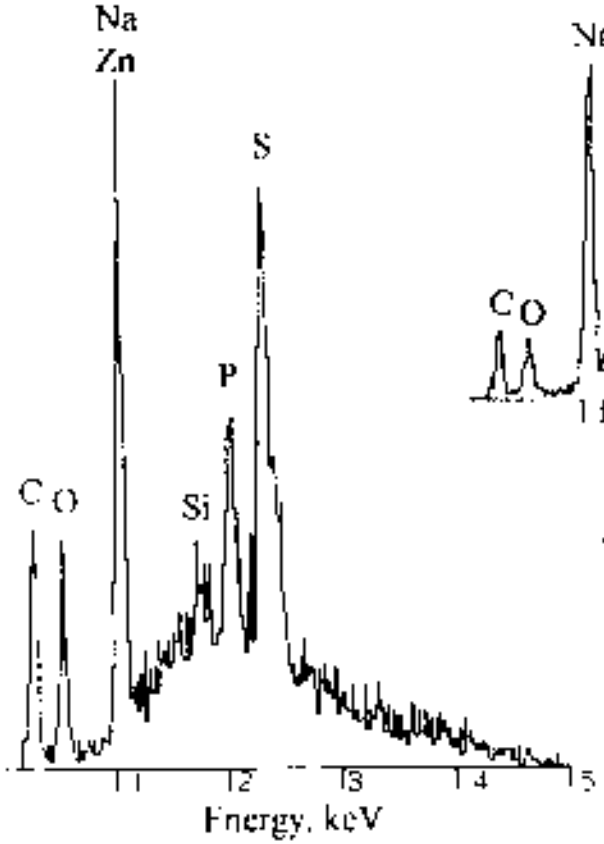
Major Constituents of PPMD Spots

- ***Carbon***
- ***Phosphorus***
- ***Sodium***
- ***Sulfur***

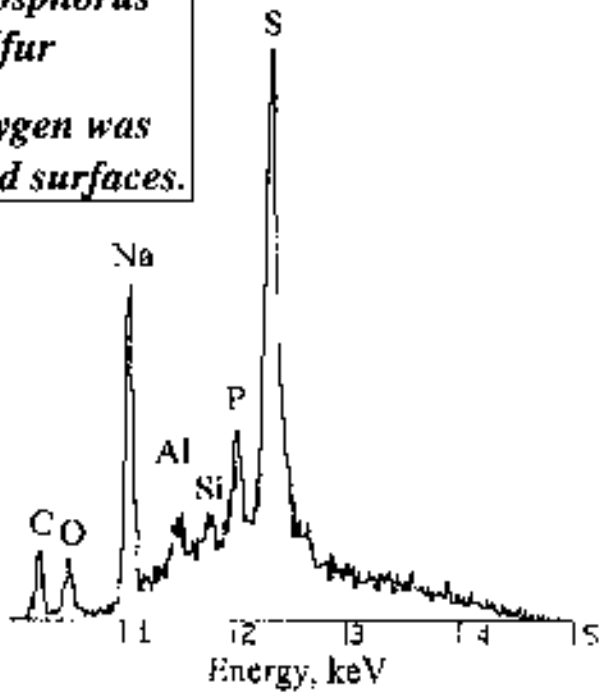
Note: The Silicon and Oxygen was detected on all exposed surfaces.



Gold Plates



Zinc Plates



Aluminum Plates

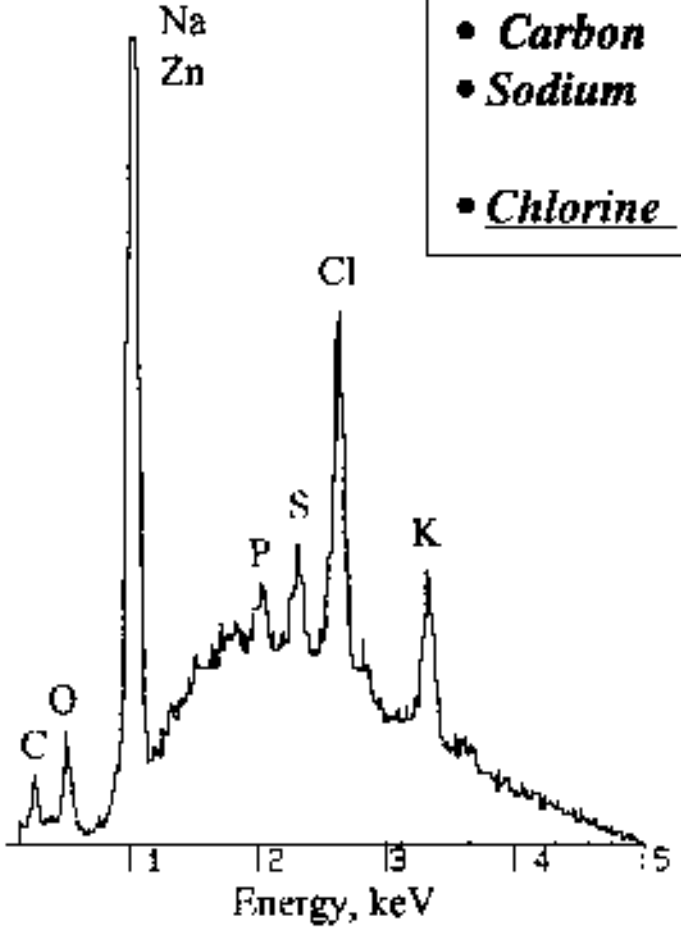
EDS Spectra of Simulated Waste Spots

Major Constituents of Human Waste Spots

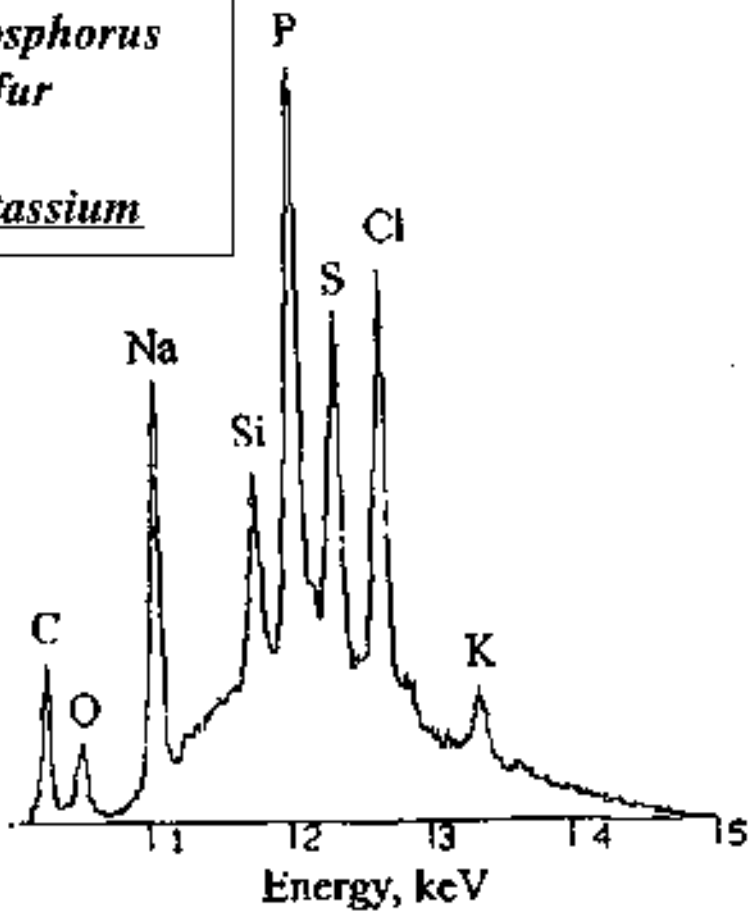
- ***Carbon***
- ***Sodium***
- ***Phosphorus***
- ***Sulfur***

and

- ***Chlorine***
- ***Potassium***



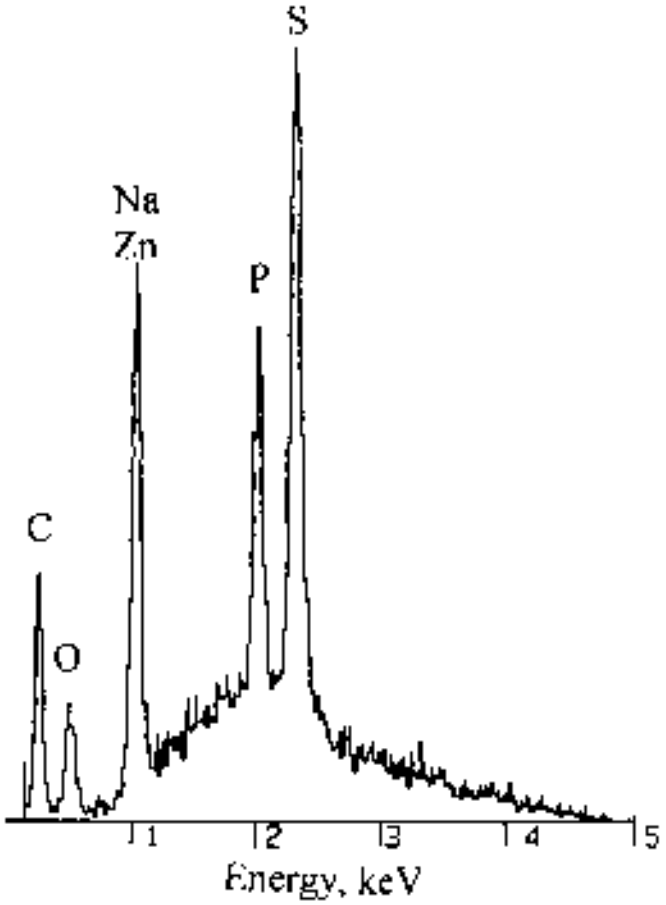
Urine Spots on Zinc



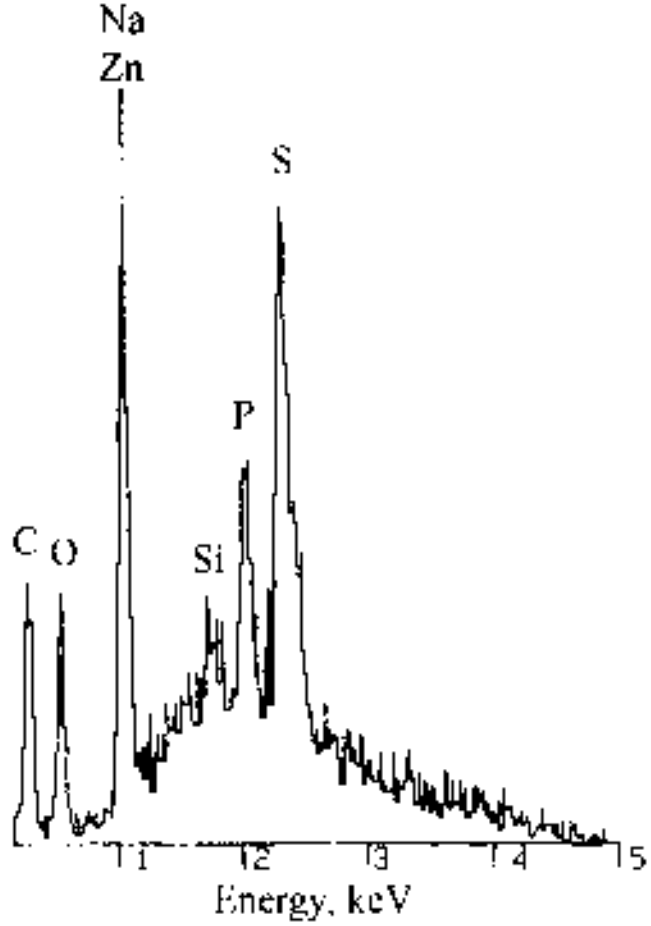
STS Waste Spots on Gold

Comparison - EDS Spectra of Soap Spots & PPMD Spots

Very good match



Soap (Alconox) Spot on Zn



PPMD Spot on Zn

Summary & Conclusions

- *The analysis of the fluid splash spots on the returned PEC and PPMD hardware has not resulted in a positive identification of the source.*

- *The fluid which resulted in the PPMD spots came from the direction of the Orbiter. The trajectory indicated by the spots is consistent with an Orbiter waste dump in the ram direction. In a ram facing dump, drag forces would decelerate the drops allowing the PPMD surfaces to over take and impact them in seconds.*

- *STS operational personnel have stated, however, that the Orbiter waste dumps involve both crew waste and condensate water and that they are made only in the wake direction.*

- *Human waste was not seen in the chemical analysis of the PPMD spots .The chemical analysis of spots simulated with detergent are, however, consistent with the PPMD spots.*

- *Mir has no normal operational fluid dumps. There have been accidental dumps from Mir and the Mir logistic vehicles, however, there is insufficient data available to confirm whether or not fluid from these dumps struck the PPMD.*